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McMillan et al.

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(54) **HANDLING AND PROCESSING DOUBLE-SIDED DEVICES ON FRAGILE SUBSTRATES**

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C23F 1/00 (2006.01)
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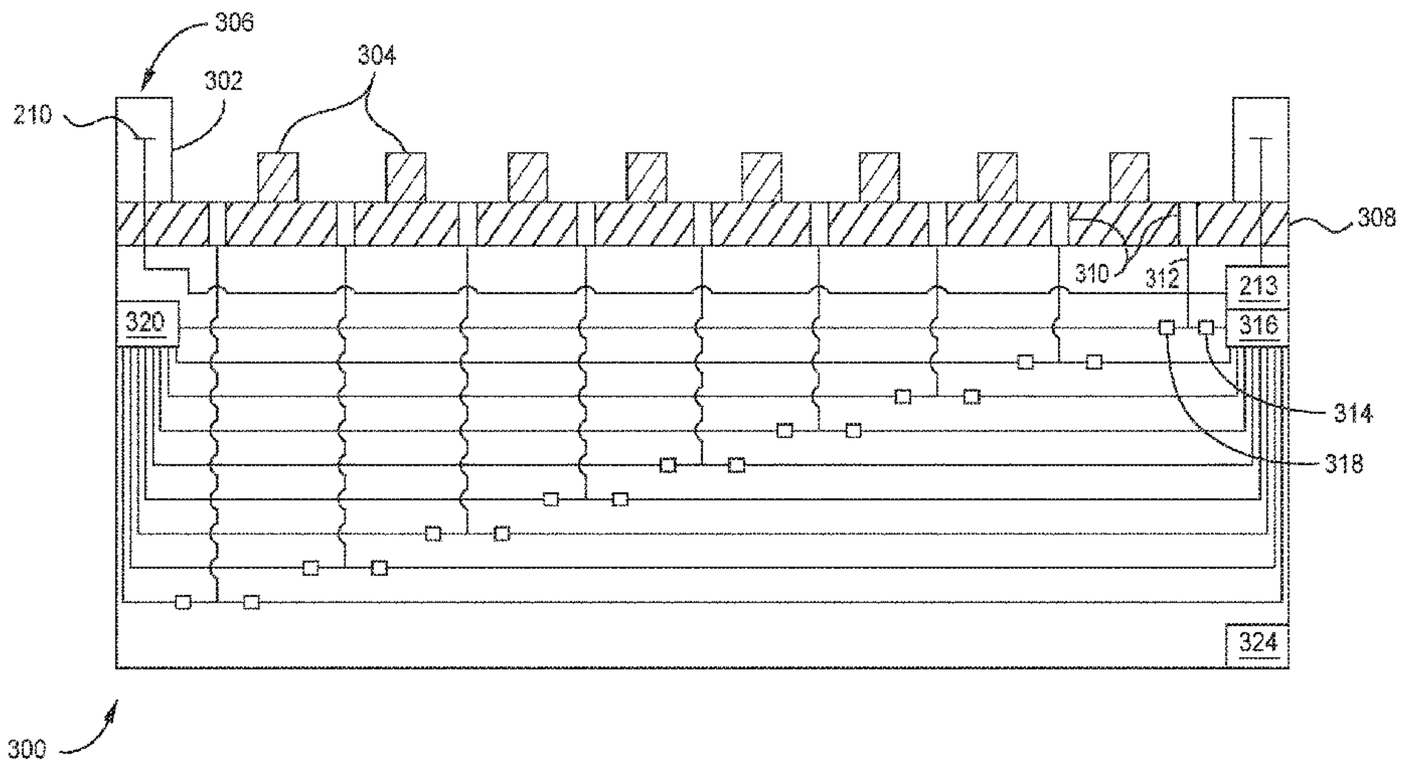
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(57) **ABSTRACT**

Embodiments of the present disclosure generally relate to substrate support assemblies for retaining a surface of a substrate having one or more devices disposed on the surface without contacting the one or more devices and deforming the substrate, and a system having the same. In one embodiment, the substrate support assembly includes an edge ring coupled to a body of the substrate support assembly. A controller is coupled to actuated mechanisms of a plurality of pixels coupled to the body of the substrate support assembly such that portions of pixels corresponding to a portion of the surface of a substrate to be retained are positioned to support the portion without contacting one or more devices disposed on the surface of the substrate to be retained on the support surface.

20 Claims, 8 Drawing Sheets



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H01L 21/683	(2006.01)
C23C 16/453	(2006.01)
H05H 1/24	(2006.01)
H01L 21/265	(2006.01)

(52) **U.S. Cl.**
CPC *H01L 21/265* (2013.01); *H01L 21/683* (2013.01); *H01L 21/6833* (2013.01); *H05H 1/24* (2013.01)

(58) **Field of Classification Search**
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USPC 361/234
See application file for complete search history.

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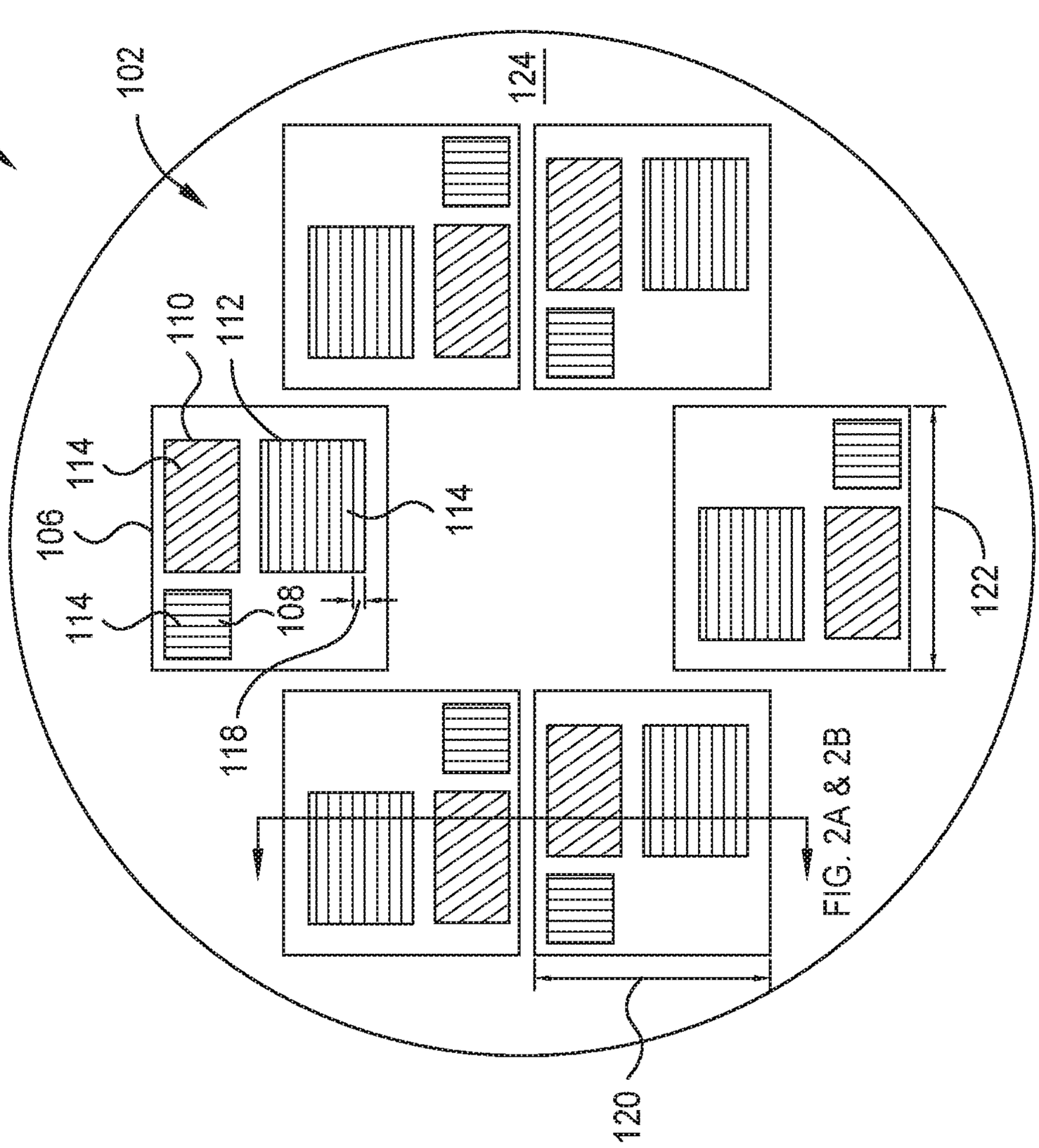


FIG. 1

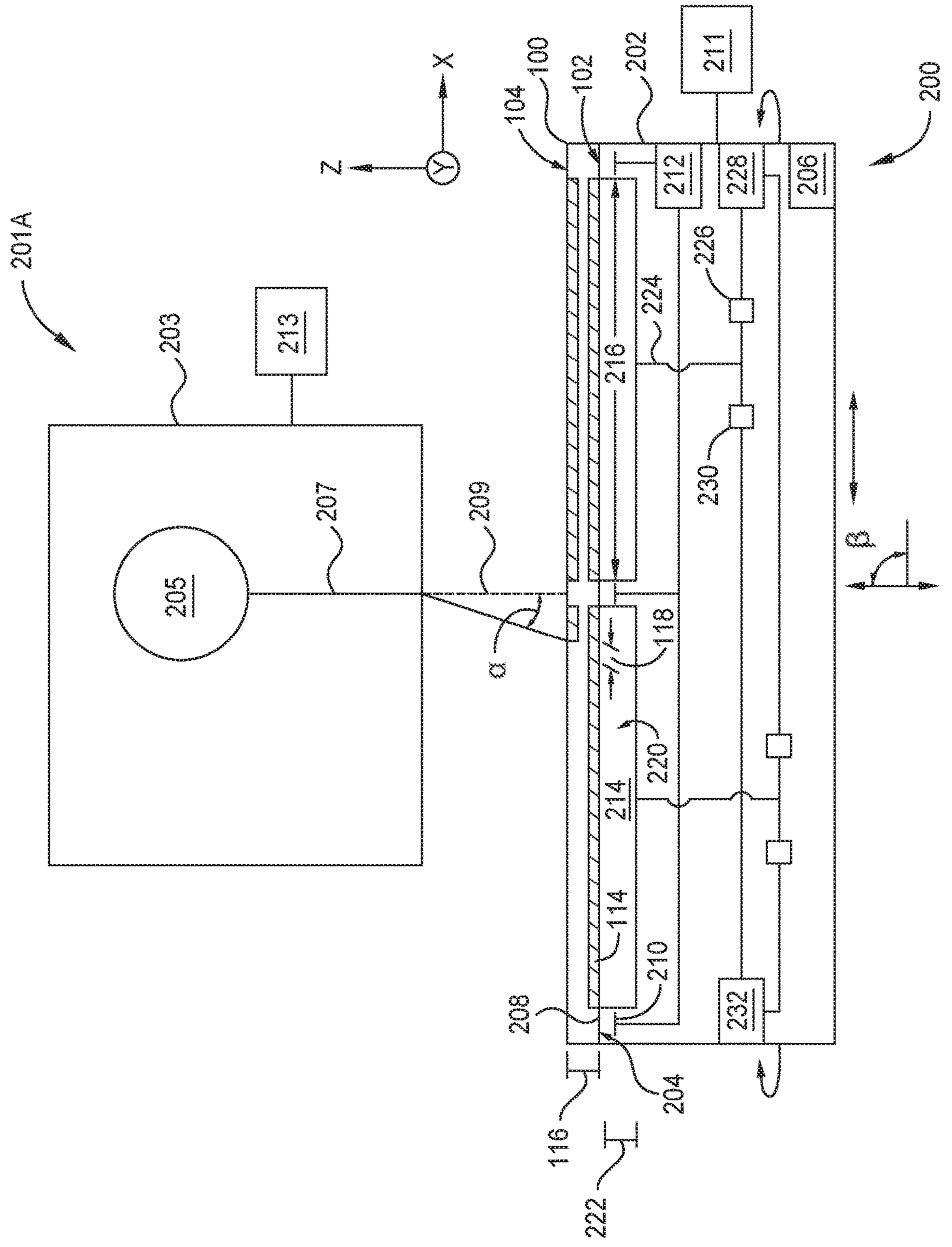

201A
203
213
205
207
209
α
Z
Y
X
104
100
102
202
211
200
212
228
206
226
224
216
230
118
214
220
β
208
210
114
232
204
116
222

FIG. 2A

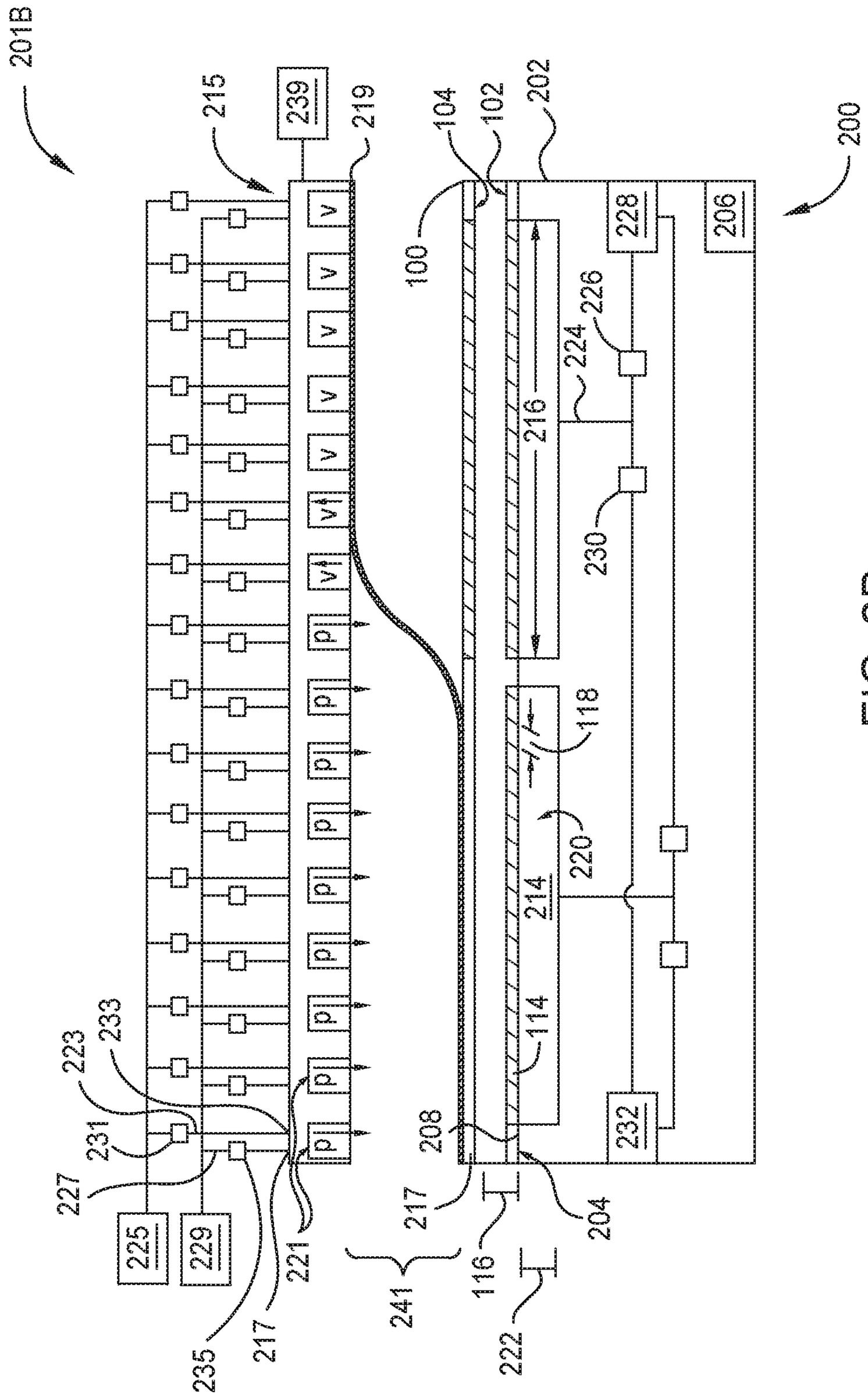

201B
215
239
219
202
104
102
200
100
228
206
226
224
216
230
118
220
214
223
233
231
227
225
229
221
217
235
208
241
116
222
204
232
114

FIG. 2B

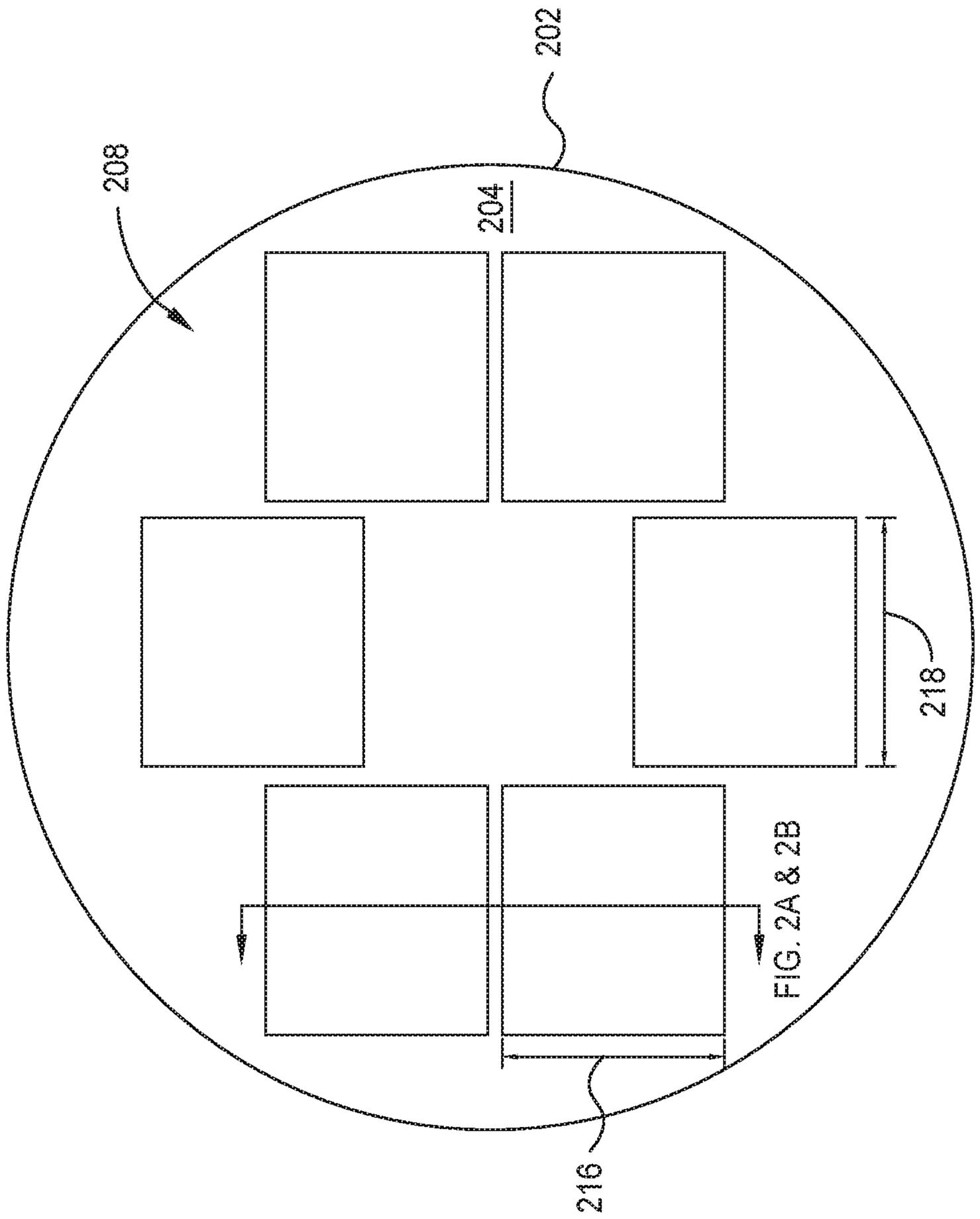


FIG. 2C

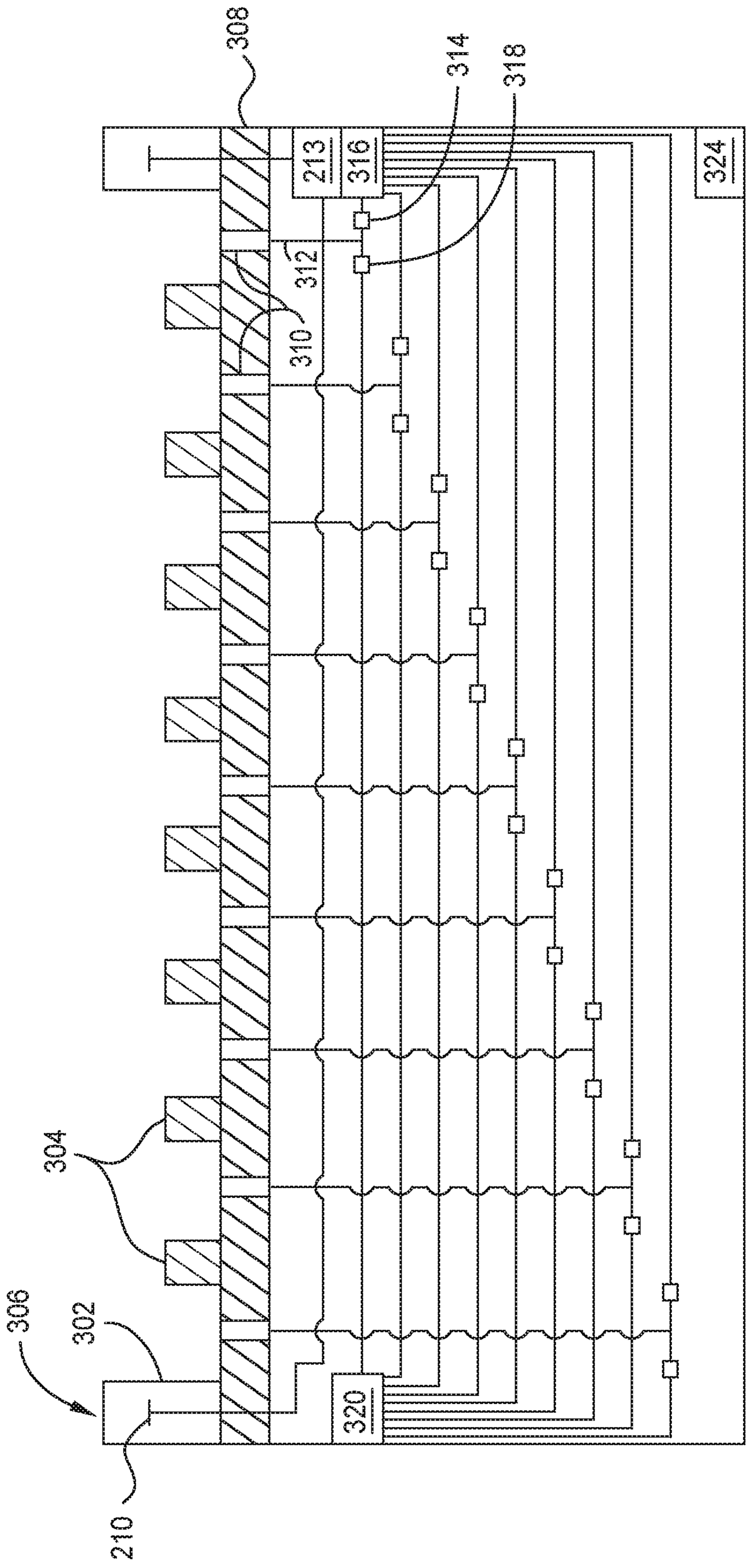


FIG. 3A

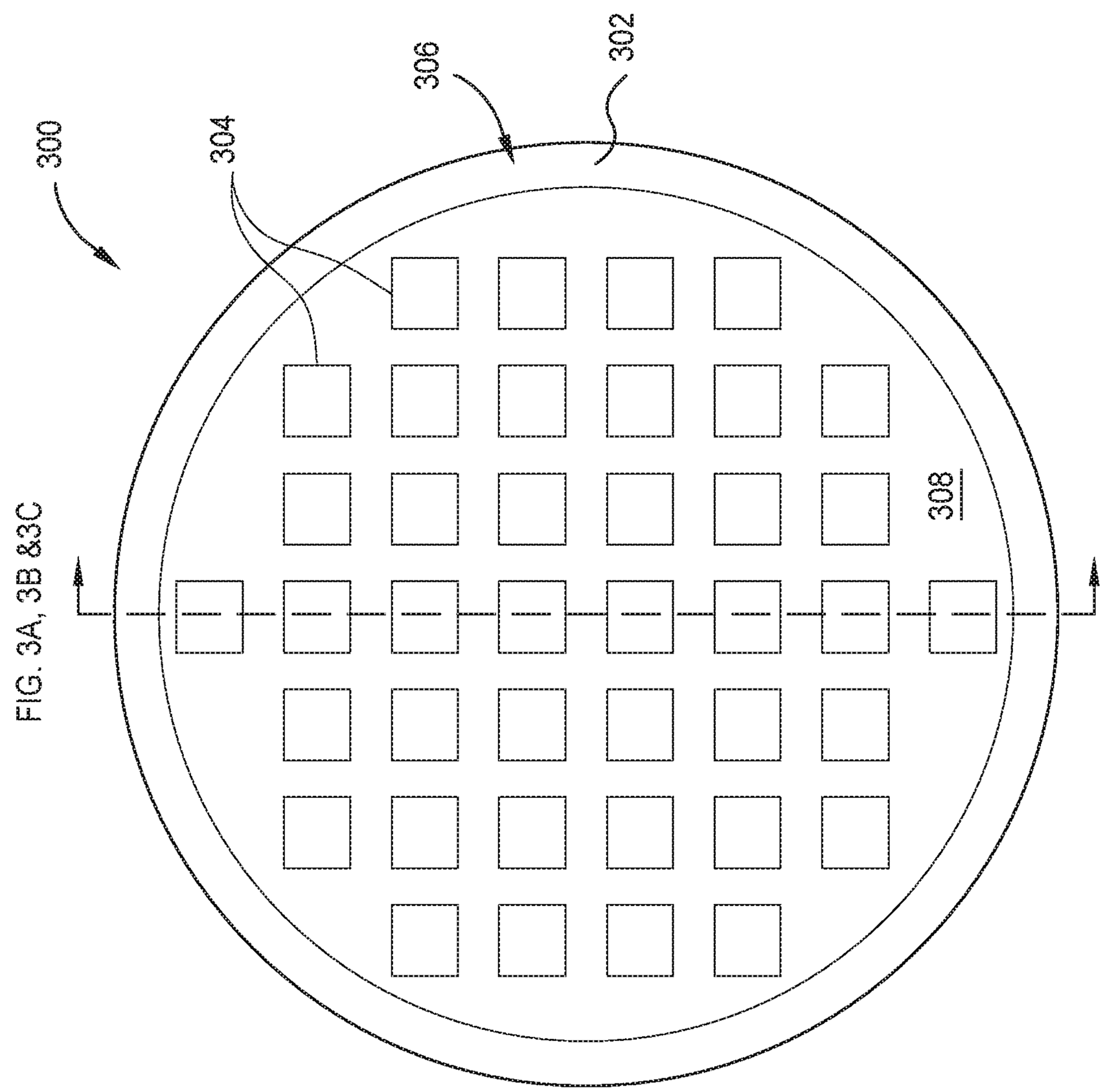


FIG. 3B

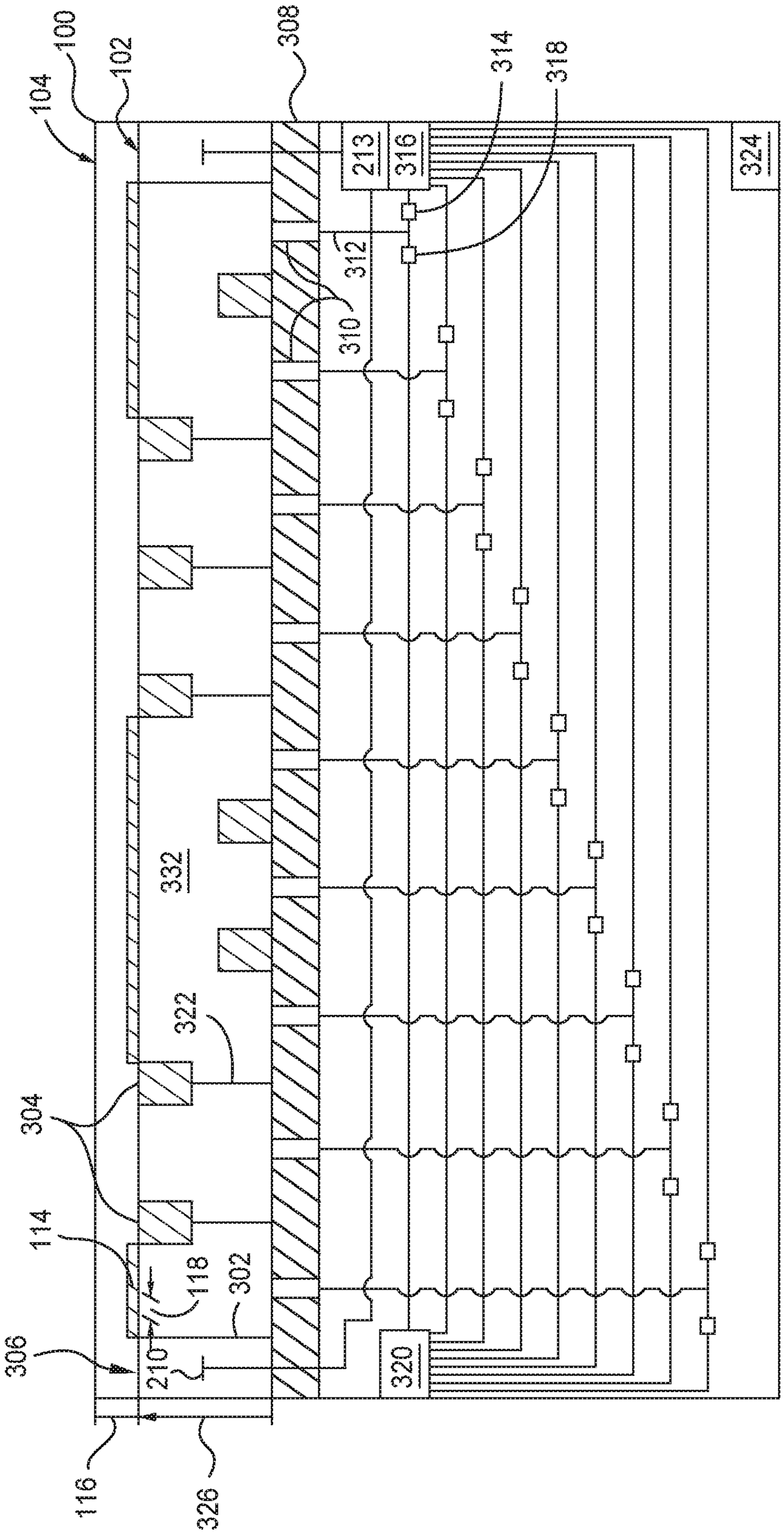

104
100
102
308
314
318
213
316
324
312
310
332
322
304
114
118
302
306
210
320
116
326

FIG. 3C

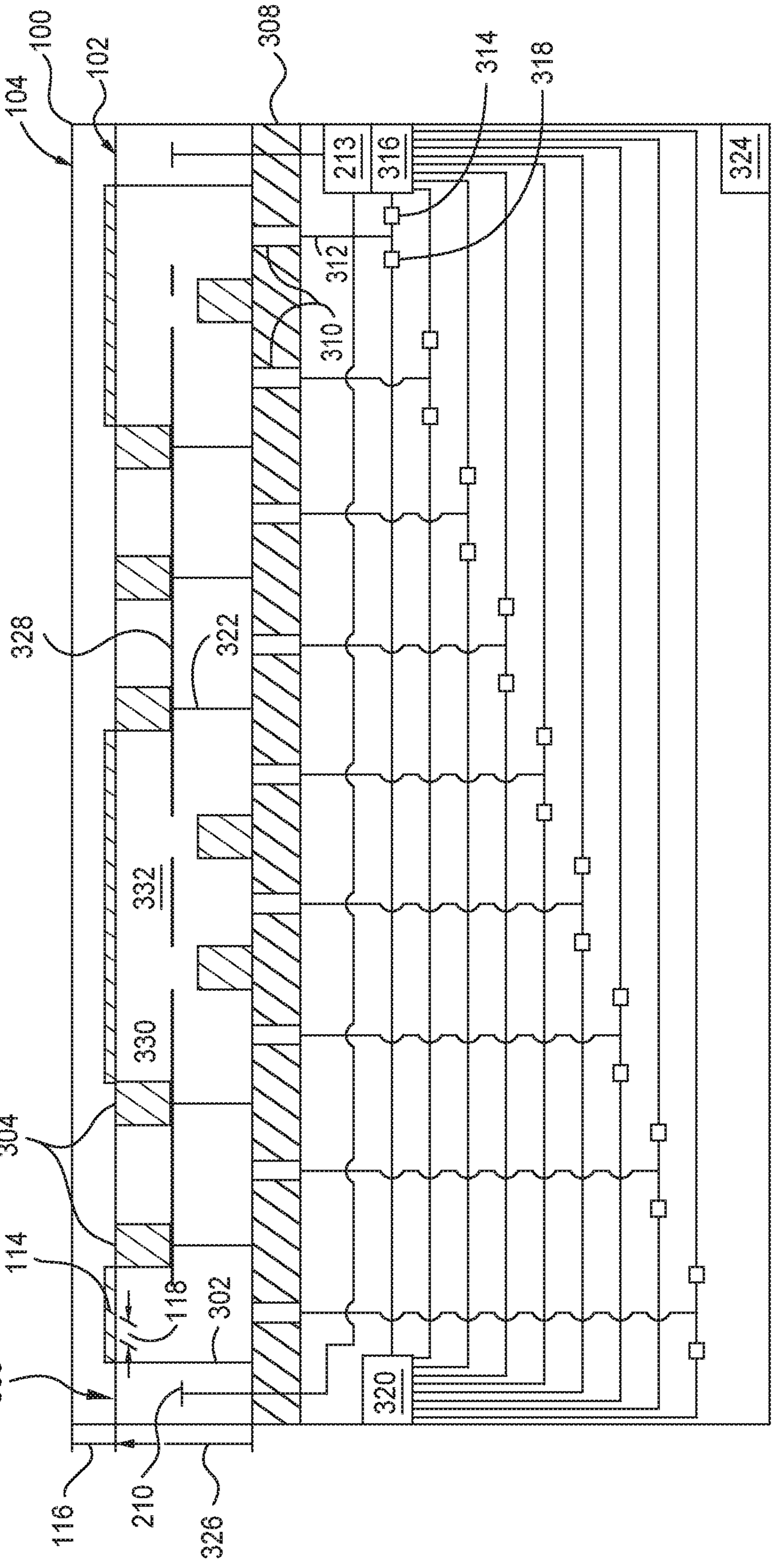

104
100
102
308
314
318
213
316
324
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310
328
322
332
330
304
114
118
302
306
320
116
210
326
300

FIG. 3D

HANDLING AND PROCESSING DOUBLE-SIDED DEVICES ON FRAGILE SUBSTRATES

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Patent Application Ser. No. 62/780,025, filed on Dec. 14, 2018, which herein is incorporated by reference.

BACKGROUND

Field

Embodiments of the present disclosure generally relate to substrate support assemblies for retaining a surface of a substrate having one or more devices disposed on the surface without contacting the one or more devices and deforming the substrate, and a system having the same.

Description of the Related Art

In the manufacture of optical devices, one or more devices having structures with sub-micron critical dimensions are disposed on two or more sides of a substrate, such as a front side and a backside of the substrate. To manufacture optical devices, such as waveguide combiners, a surface of the substrate having the one or more devices disposed on the surface must be retained on a substrate support assembly without contacting the one or more devices. Contacting the one or more devices may damage the devices. Furthermore, the substrate may include fragile materials, such as glass, and may have a thickness less than about 1 millimeter (mm). The combination of the fragile materials and the thickness may result in deformation of the substrate. Accordingly, what is needed in the art is substrate support assemblies for retaining a surface of a substrate having one or more devices disposed on the surface without contacting the one or more devices and deforming the substrate, and a system having the same.

SUMMARY

In one embodiment, a substrate support assembly is provided. The substrate support assembly includes a plurality of projections coupled to a body of the substrate support assembly. Each of the plurality of projections have a support surface corresponding to a portion of a surface of a substrate to be retained on the support surface. A plurality of pockets are defined by adjacent projections of the plurality of projections. Each of the plurality of pockets has a pocket width corresponding to a width of one or more devices disposed on the surface of the substrate to be retained on the support surface, a pocket length corresponding to a length of the one or more devices disposed on the surface of the substrate to be retained on the support surface, and a pocket conduit operable to be in fluid communication with a vacuum source via a vacuum flow controller and operable to be in fluid communication with a gas source via a gas flow controller.

In another embodiment, a substrate support assembly is provided. The substrate support assembly includes an edge ring coupled to a plate. The edge ring has a support surface corresponding to a portion of a surface of a substrate to be retained on the support surface. A plurality of pixels are coupled to a plurality of actuated mechanisms coupled to the substrate support assembly. Each of the plurality of pixels correspond to an actuated mechanism of the plurality of actuated mechanisms. A controller is coupled to each actuated mechanism such that portions of pixels corresponding to the portions of the surface of the substrate to be retained are positioned to support the portions without contacting one or more devices disposed on the surface of the substrate to be retained on the support surface.

In yet another embodiment, a substrate support assembly is provided. The substrate support assembly includes an edge ring coupled to a plate. The edge ring has a support surface corresponding to a portion of a surface of a substrate to be retained on the support surface. The substrate support assembly includes a plurality of pixels and a pixel support plate coupled to an actuated mechanism. The pixel support plate has a pattern of a plurality of holes corresponding to one or more devices of the portion of the surface of the substrate to be retained such that each pixel of the plurality of pixels raised to a support position does not contact the one or more devices.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only exemplary embodiments and are therefore not to be considered limiting of its scope, and may admit to other equally effective embodiments.

FIG. **1** is a schematic, top view of a first surface of a substrate according to an embodiment.

FIG. **2**A is a schematic, cross-sectional view of a system including a substrate support assembly according to an embodiment.

FIG. **2**B is a schematic, cross-sectional view of a system including a substrate support assembly according to an embodiment.

FIG. **2**C is a schematic, top view of a substrate support assembly according to an embodiment.

FIGS. **3**A, **3**C, and **3**D are schematic, cross-sectional views of a substrate support assembly according to an embodiment.

FIG. **3**B is a schematic, top view of a substrate support assembly according to an embodiment.

To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. It is contemplated that elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

Embodiments of the present disclosure generally relate to substrate support assemblies for retaining a surface of a substrate having one or more optical devices disposed on the surface without contacting the one or more optical devices and deforming the substrate, and a system having the same. The substrate support assemblies described herein provide for the retention of a substrate without contacting the one or more optical devices formed on the substrate and without deforming the substrate, including fragile materials having a thickness less than about 1 mm.

FIG. **1** is a perspective, frontal view of a first surface **102** (i.e., top surface) of the substrate **100**. The substrate **100** includes a second surface **104** (i.e., bottom surface) opposite the first surface **102**. The substrate **100** may be glass, plastic, and polycarbonate, or any other suitable material. The materials may have rollable and flexible properties. In one embodiment, which can be combined with other embodiments described herein, the substrate **100** has a thickness **116** (shown in FIGS. **2**A, **2**B, **3**C, and **3**D) less than about 1 millimeter (mm). In some embodiments, the thickness is less than 0.5 mm. The substrate **100** includes one or more optical devices **106**, such as waveguide combiners, disposed on the first surface **102** and/or the second surface **104** of the substrate. The one or more optical devices **106** can include one or more gratings, such as an input grating **108**, an intermediate grating **110**, and an output grating **112**. Each of the input grating **108**, an intermediate grating **110**, and an output grating **112** include structures **114** (i.e., fins) having sub-micron critical dimensions, e.g., nano-sized critical dimensions. In one embodiment, which can be combined with other embodiments described herein, the one or more optical devices **106** include structures **114** having critical dimensions **118** less than 1 micrometer (μm).

The embodiments of the substrate support assembly **200** (shown in FIGS. **2**A and **2**B) and substrate support assembly **300** (shown in FIGS. **3**A-**3**D) described herein are operable to retain the substrate **100** having one or more optical devices **106** without contacting the structures **114** and without deforming the substrate **100**. FIG. **2**A is a schematic, cross-sectional view of a system **201**A including a substrate support assembly **200**. The system **201**A is shown configured as an angled etch system, such as the Varian VIISta® Raptor DRB® system available from Applied Materials, Inc. located in Santa Clara, Calif. It is to be understood that the system **201**A described below is an exemplary system and other systems, including systems from other manufacturers, may be used with or modified to include the substrate support assembly **200**. For example, the substrate support assembly **200** may be utilized in chemical vapor deposition (CVD) systems, plasma-enhanced CVD (PECVD) systems, ion implantation chambers, among others, as well as other systems utilized in manufacturing optical devices.

The system **201**A includes an ion beam chamber **203** that houses an ion beam source **205**. The ion beam source **205** is configured to generate an ion beam **207**, such as a ribbon beam, a spot beam, or a full substrate-size beam. The ion beam **207** is operable to form the structures **114** having sub-micron critical dimensions in the substrate **100** or material disposed on the substrate **100**. The ion beam chamber **203** is configured to direct the ion beam **207** at an optimized angle α relative to a surface normal **209** of a substrate **100**. The substrate **100** is retained on a support surface **204** of the substrate support assembly **200** described in further detail herein. In one embodiment, which can be combined with other embodiments described herein, a body **202** of the substrate support assembly **200** is coupled to an actuator **211**. The actuator **211**, in operation, moves the body **202** in a scanning motion along a y-direction and/or a z-direction. In one embodiment, which can be combined with other embodiments described herein, the actuator **211**, in operation, tilts the body **202** such that the substrate **100** is positioned at a tilt angle β relative to the x-axis of the ion beam chamber **203**. In another embodiment, which can be combined with other embodiments described herein, the actuator **211**, in operation, rotates the substrate **100** about the x-axis of the body **202**. The substrate support assembly **200** includes a controller **206** operable to be in communication with a system controller **213** and is operable to control aspects of the substrate support assembly **200** during processing.

FIG. **2**B is a schematic, cross-sectional view of a system **201** B including the substrate support assembly **200**. The system **201**B is shown configured as a nano-imprint lithography system. The system **201**B includes a stamp holder **215** operable to contact and release a stamp **219** into an imprint material **217** disposed on the substrate **100** to form structures **114** having sub-micron critical dimensions in the imprint material **217** disposed on the substrate **100**. The stamp holder **215** is operable to contact and release the stamp **219** into the imprint material **217** via pressure differentials in a region **241** defined between the stamp holder **215** and the support surface **204** of the substrate support assembly **200**. In one embodiment, which can be combined with other embodiments described herein, the stamp holder **215** includes a plurality of ports **221**. The plurality of ports **221** are coupled to a plurality of pressure lines **223** and a plurality of vacuum lines **227**. The plurality of pressure lines **223** are coupled to a pressure manifold **225**. The plurality of vacuum lines **227** are coupled to a vacuum manifold **229**. The pressure manifold **225** is operable to supply pressure through the ports **221** to the region **241** to force portions of a stamp **219** corresponding to the ports **221** having pressure supplied by the pressure manifold **225** to contact the imprint material **217** of the substrate **100**. The vacuum manifold **229** is operable to supply vacuum through the ports **221** to the region **241** to release portions of a stamp **219** corresponding to the ports **221** having vacuum supplied by the vacuum manifold **229** from contact with the imprint material **217** of the substrate **100**.

Each port of the plurality of ports **221** is coupled to the pressure manifold **225** via a respective pressure line of the plurality of pressure lines **223**. Each pressure line has a flow controller **231**, such as a mass flow controller (MFC), disposed between a pressure line outlet **233** and the pressure manifold **225**. Each port of the plurality of ports **221** is coupled to the vacuum manifold **229** via a respective vacuum line of the plurality of vacuum lines **227**. Each vacuum line has a flow controller **235**, such as a MFC, disposed between an vacuum line outlet **237** and the vacuum manifold **229**. Each flow controller **231** of the plurality of pressure lines **223** and each flow controller **235** of the plurality of vacuum lines **227** is coupled to a system controller **239**. The system controller **239** is operable to operate each flow controller **231** and each flow controller **235** such that portions of the stamp **219** are able to contact and release from the imprint material **217** according to embodiments described herein.

As shown in FIGS. **2**A and **2**B, and FIG. **2**C, a schematic, top view of the substrate support assembly **200**. The body **202** of the substrate support assembly **200** includes a plurality of projections **208**. In some embodiments, shown in FIG. **2**A, which can be combined with other embodiments described herein, each projection of the plurality of projections **208** includes a chucking electrode **210** disposed therein. Each chucking electrode **210** may be configured in a monopolar electrode, bipolar electrode, or other suitable arrangement. Each chucking electrode **210** is coupled to a chucking power source **212**, which provides DC power to electrostatically secure the substrate **100** to the support surface **204** of the plurality of projections **208**. In one embodiment, which can be combined with other embodiments described herein, the body **202** and the projections **208** include stainless steel and/or aluminum containing materials. In another embodiment, which can be combined

with other embodiments described herein, the body **202** and the projections **208** include ceramic containing materials.

The first surface **102** (i.e., top surface) of the substrate **100** is securable to the support surface **204** of the plurality of projections **208** without the one or more optical devices **106** contacting the support surface **204**. Adjacent projections of the plurality of projections **208** form pockets **214**. The pockets **214** have a width **216** and a length **218** corresponding to a width **120** and a length **122** (as shown in FIG. **1**) of the one or more optical devices **106**. The plurality of projections **208** correspond to portions **124** of one of the first surface **102** and the second surface **104** without one of the optical devices **106** disposed thereon. When the substrate **100** is secured to the support surface **204** of the substrate support assembly **200**, regions **220** are formed, in each of the pockets **214**, between the body **202** of the substrate support assembly **200** and the optical devices **106** of one of the first surface **102** and second surface **104** secured to the support surface **204**.

In one embodiment, which can be combined with other embodiments described herein, the width **216** and the length **218** of one or more of the pockets **214** are different. The width **216** and the length **218** of one or more of the pockets **214** are different such that the plurality of projections **208** are operable to support the substrate **100** having one or more optical devices **106** with a different width **120** and a different length **122**. In another embodiment, the width **216** and the length **218** are the same. In one embodiment, which can be combined with other embodiments described herein, the width **216** and the length **218** are about 20 mm to about 60 mm. In one embodiment, which can be combined with other embodiments described herein, a depth **222** of the one or more of the pockets **214** is about 0.5 mm to 1 mm. In another embodiment, which can be combined with other embodiments described herein, the depth **222** is about 0.02 mm or less.

Each of the pockets **214** are operable to be coupled to a pocket conduit **224** in fluid communication with a vacuum source **228** via a vacuum flow controller **226**, such as a MFC, and each of the pockets **214** are operable to be coupled to the pocket conduit **224** in fluid communication with a gas source **232** via a gas flow controller **230**. The vacuum manifold **229** is operable to supply vacuum pressure through a respective pocket conduit **224** to a respective pocket **214** to retain portions of the substrate **100** corresponding to the support surface **204** of the projections **208** by maintaining a vacuum pressure in a respective region **220**. In one embodiment, which can be combined with other embodiments described herein, the vacuum pressure is about 380 Torr to about 760 Torr. The gas source **232** is operable to provide gas through a respective pocket conduit **224** to a respective pocket **214** to perform at least one of pressurize the respective region **220**, maintain the substrate **100** at a cryogenic processing temperature, and release the portions of the substrate **100** from the support surface **204** of the projections **208**. The controller **206** is operable to operate each vacuum flow controller **226** and each gas flow controller **230** according to embodiments described herein.

In one embodiment, which can be combined with other embodiments, the gas source **232** is operable to flow inert gas though the pocket conduit **224** to pressurize the regions **220**. In the embodiments shown in FIG. **2**A, the pressurized regions **220** neutralize substrate deformation, such as deformation of the one or more optical devices **106**, when the portions **124** are secured to the support surface **204** via forces generated by the chucking electrode **210** of each of the plurality of projections **208**. The inert gas may include hydrogen gas (H_2), helium (He), argon (Ar), and/or nitrogen gas (N_2).

In another embodiment, which can be combined with other embodiments described herein, the inert gas has a cryogenic temperature less than −50 degrees Celsius to maintain the substrate **100** at a cryogenic processing temperature less than about −20 degrees Celsius. Maintaining the substrate **100** at a cryogenic processing temperature allows for etching of the one or the first surface **102** and second surface **104** to form structures **114** with smooth sidewalls. For example, ion etching, as shown in FIG. **2**A, the substrate **100** maintained at the cryogenic processing temperature enables ions to bombard the upward-facing surfaces of materials disposed on the substrate **100** with decreased spontaneous etching. Additionally, the selectivity of etching one material versus another can be improved at the cryogenic processing temperature. For example, selectivity between silicon (Si) and silicon dioxide (SiO_2) increases exponentially as the temperature is decreased. In one embodiment, which can be combined with other embodiments described herein, the backside cooling pressure in the regions **220** is about 2 Torr to about 50 Torr.

In yet another embodiment, as shown in FIG. **2**B, which can be combined with other embodiments described herein, the first surface **102** (i.e., top surface) of the substrate **100** is securable to the support surface **204** of the plurality of projections **208** without the one or more optical devices **106** contacting the support surface **204**. The substrate **100** is retained on the support surface **204** by maintaining the vacuum pressure in the regions **220**. As described above, the pressure manifold **225** is operable to supply pressure through the ports **221** to the region **241** to force portions of a stamp **219** corresponding to the ports **221** having pressure supplied by the pressure manifold **225** to contact the imprint material **217** of the substrate **100**. As the stamp **219** is removed from portions of the second surface **104**, the regions **220** corresponding to the portions of the second surface **104** are pressurized by the gas source **232**. As described above, the vacuum manifold **229** is operable to supply vacuum through the ports **221** to the region **241** to release portions of a stamp **219** corresponding to the ports **221** having vacuum supplied by the vacuum manifold **229** from contact with the imprint material **217** of the substrate **100**. Deformation of the structures **114** of the one or more optical devices **106** may occur due to the pressure differential in the region **241**. Thus, the pressurized regions **220** neutralize substrate deformation when the stamp **219** is release by the stamp holder **215**.

FIGS. **3**A, **3**C, and **3**D are schematic, cross-sectional views of a substrate support assembly **300**. FIG. **3**B is a schematic, top view of the substrate support assembly **300**. The substrate support assembly **300** includes an edge ring **302** and a plurality of pixels **304**. The edge ring **302** includes a support surface **306**. In one embodiment, which can be combined with other embodiments described herein, the edge ring **302** and the plurality of pixels **304** include stainless steel and/or aluminum containing materials. In another embodiment, which can be combined with other embodiments described herein, the edge ring **302** and the plurality of pixels **304** include ceramic containing materials.

In one embodiment, which can be combined with other embodiments described herein, the edge ring **302** includes the chucking electrode **210** disposed therein. The chucking electrode **210** coupled to the chucking power source **212**, which provides a DC power to electrostatically secure the substrate **100** to the support surface **306** of the edge ring **302**.

In another embodiment, which can be combined with other embodiments described herein, the substrate support assembly **300** includes a plate **308** having a plurality of channels **310**. Each channel of the plurality of channels **310** is coupled to a channel conduit **312** operable to be in fluid communication with a vacuum source **316** via a vacuum flow controller **314**, such as an MFC. Each channel conduit **312** is operable to be in fluid communication with a gas source **320** via a gas flow controller **318**. A controller **324** is operable to operate each vacuum flow controller **314** and each gas flow controller **318** according to embodiments described herein.

As shown in FIG. **3**C, each pixel of the plurality of pixels **304** includes an actuated mechanism **322** coupled to the controller **324**. The actuated mechanism **322** includes a mechanism operable to raise a pixel of the plurality of pixels **304** to a support position **326**, shown in FIG. **3**C. For example, the actuated mechanism **322** includes at least one of a spring mechanism, a magnet mechanism, and a pneumatic mechanism. The controller **324** is operable to individually control the actuated mechanism **322** of each of the plurality of pixels **304** such that a portion of the plurality of pixels **304** is raised. Each of the plurality of pixels **304** are individually controlled such that the substrate support assembly **300** is operable to support the substrate **100** having one or more optical devices **106** with a different width **120** and a different length **122** without contracting the optical devices **106**. Additionally, the individually controlled plurality of pixels **304** provides for supporting various configurations of the substrate **100** having one or more optical devices **106**.

As shown in FIG. **3**D, the substrate support assembly **300** includes a pixel support plate **328**. The pixel support plate **328** is coupled to an actuated mechanism **322**. The pixel support plate **328** includes a pattern of a plurality of holes **330**. Each hole of the plurality of holes **330** corresponds to the one or more optical devices **106** such that each pixel of the plurality of pixels **304** not in the support position **326** does not contact the one or more optical devices **106**. The controller **324** is operable to control the actuated mechanism **322** such that a portion of the plurality of pixels **304** is raised by the pixel support plate **328**. Raising the pixel support plate **328** positions the portion of the plurality of pixels **304** in the support position **326**, shown in FIG. **3**D. The support position **326**, as shown in FIGS. **3**C and **3**D, of the portion of the plurality of pixels **304** corresponds to the portions **124** of one of the first surface **102** and the second surface **104** to be supported by the support surface **306** of the edge ring **302** and the portion of the plurality of pixels **304**. The pixel support plate **328** is interchangeable such that pixel support plates having different patterns of the plurality of holes **330** may be utilized to support various configurations of the substrate **100** having one or more optical devices **106**.

The support position **326** is a depth from the support surface **306** of the one or more raised pixels **304** to the plate **308**. In one embodiment, which can be combined with other embodiments described herein, the depth of the support position **326** is about 0.5 mm to 1 mm. In another embodiment, which can be combined with other embodiments described herein, the depth of the support position **326** is about 0.02 mm or less. When the substrate **100** is secured to the support surface **306** of the edge ring **302** and the portion of the plurality of pixels **304**, regions **332** are formed between adjacent pixels **304** and the edge ring **302** and pixels **304** adjacent to the edge ring. In one embodiment, which can be combined with other embodiments, the gas source **320** is operable to flow inert gas though channel conduits **312** to pressurize the regions **332**. In embodiments with use of the system **201**A, which can be combined with other embodiments described herein, the pressurized regions **332** neutralize substrate deformation, such as deformation of the one or more optical devices **106**, when the portions **124** are secured to the support surface **306** via forces generated by the chucking electrode **210**.

In another embodiment, which can be combined with other embodiments described herein, the inert gas has a cryogenic temperature less than −50 degrees Celsius to maintain the substrate **100** at a cryogenic processing temperature less than about −20 degrees Celsius. In one embodiment, which can be combined with other embodiments described herein, the backside cooling pressure in the regions **332** is about 2 Torr to about 50 Torr. regions **332**

In embodiments with use of the system **201**B, which can be combined with other embodiments described herein, the first surface **102** (i.e., top surface) of the substrate **100** is securable to the support surface **306** of the plurality of pixels **304** without the one or more optical devices **106** contacting the support surface **306**. The substrate **100** is retained on the support surface **306** by maintaining the vacuum pressure in the regions **332**. In one embodiment, which can be combined with other embodiments described herein, the vacuum pressure is about 380 Torr to about 760 Torr. As the stamp **219** is removed from portions of the second surface **104**, the regions **332** corresponding to the portions of the second surface **104** are pressurized by the gas source **320**. Deformation of the structures **114** of the one or more optical devices **106** may occur due to the pressure differential in the region **241**. Thus, the pressurized regions **332** neutralize substrate deformation when the stamp **219** is released by the stamp holder **215**.

In summation, substrate support assemblies for retaining a surface of a substrate having one or more devices disposed on the surface without contacting the one or more devices, and system having the same are provided. The substrate support assemblies described herein provide for the retention of a substrate without contacting the one or more devices formed on the substrate and without deforming the substrate including fragile materials having a thickness less than about 1 mm.

While the foregoing is directed to examples of the present disclosure, other and further examples of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

What is claimed is:

1. A substrate support assembly, comprising:

a plurality of projections coupled to a body of the substrate support assembly, each of the plurality of projections having a support surface corresponding to a portion of a surface of a substrate to be retained on the support surface; and

a plurality of pockets defined by adjacent projections of the plurality of projections, each of the plurality of pockets having:

a pocket width corresponding to a width of one or more devices disposed on the surface of the substrate to be retained on the support surface;

a pocket length corresponding to a length of the one or more devices disposed on the surface of the substrate to be retained on the support surface; and

a pocket conduit operable to be in fluid communication with a vacuum source via a respective vacuum flow controller of a plurality of vacuum flow controllers and operable to be in fluid communication with a gas

source via a respective gas flow controller of a plurality of gas source controllers.

2. A substrate support assembly of claim **1**, comprising:

a plurality of projections coupled to a body of the substrate support assembly, each of the plurality of projections having a support surface corresponding to a portion of a surface of a substrate to be retained on the support surface; and

a plurality of pockets defined by adjacent projections of the plurality of projections, each of the plurality of pockets having:

a pocket width corresponding to a width of one or more devices disposed on the surface of the substrate to be retained on the support surface;

a pocket length corresponding to a length of the one or more devices disposed on the surface of the substrate to be retained on the support surface; and

a pocket conduit operable to be in fluid communication with a vacuum source via a vacuum flow controller and operable to be in fluid communication with a gas source via a gas flow controller, wherein the gas source is operable to provide gas through a respective pocket conduit to a respective pocket to at least one of:

pressurize a respective region defined by the substrate, adjacent projections, and the body of the substrate support assembly;

maintain the substrate at a cryogenic processing temperature; or

release the portion of the substrate from the support surface of the projections.

3. The substrate support assembly of claim **2**, wherein the gas source is an inert gas source.

4. The substrate support assembly of claim **3**, wherein inert gas of the inert gas source has a cryogenic temperature less than −50 degrees Celsius.

5. The substrate support assembly of claim **1**, wherein each of the plurality of projections include:

a chucking electrode disposed therein and coupleable to a power source.

6. The substrate support assembly of claim **5**, wherein the chucking electrode is configured in a monopolar or bipolar electrode arrangement.

7. The substrate support assembly of claim **1**, wherein the body and the projections include stainless steel and/or aluminum containing materials.

8. The substrate support assembly of claim **1**, wherein the pocket width and the pocket length are about 20 millimeters (mm) to about 60 mm.

9. The substrate support assembly of claim **1**, wherein a depth of the plurality of pockets is about 0.5 mm to 1 mm.

10. The substrate support assembly of claim **1**, wherein a depth of the plurality of pockets is about 0.02 mm or less.

11. A substrate support assembly, comprising:

an edge ring coupled to a plate, the edge ring having a support surface corresponding to a portion of a surface of a substrate to be retained on the support surface;

a plurality of pixels coupled to a plurality of actuated mechanisms coupled to the substrate support assembly, each of the plurality of pixels corresponding to an actuated mechanism of the plurality of actuated mechanisms; and

a controller coupled to each actuated mechanism such that portions of pixels corresponding to the portions of the surface of the substrate to be retained are positioned to support the portions of the surface without contacting one or more devices disposed on the surface of the substrate to be retained on the support surface.

12. The substrate support assembly of claim **11**, wherein the plate includes a plurality of channels.

13. The substrate support assembly of claim **12**, wherein each channel of the plurality of channels is coupled to a channel conduit operable to be in fluid communication with a vacuum source via a vacuum flow controller and operable to be in fluid communication with a gas source via a gas flow controller.

14. The substrate support assembly of claim **11**, wherein the edge ring includes a chucking electrode disposed therein and coupleable to a power source.

15. The substrate support assembly of claim **14**, wherein the chucking electrode is configured in a monopolar or bipolar electrode arrangement.

16. The substrate support assembly of claim **11**, wherein the edge ring and the plurality of pixels include stainless steel and/or aluminum containing materials.

17. The substrate support assembly of claim **11**, wherein each actuated mechanism includes at least one of a spring mechanism, a magnet mechanism, and a pneumatic mechanism.

18. A substrate support assembly, comprising:

an edge ring coupled to a plate, the edge ring having a support surface corresponding to a portion of a surface of a substrate to be retained on the support surface;

a plurality of pixels; and

a pixel support plate coupled to an actuated mechanism, the pixel support plate having a pattern of a plurality of holes corresponding to one or more devices of the portion of the surface of the substrate to be retained such that each pixel of the plurality of pixels raised to a support position does not contact the one or more devices.

19. The substrate support assembly of claim **18**, wherein:

the plate includes a plurality of channels; and

each channel of the plurality of channels is coupled to a channel conduit operable to be in fluid communication with a vacuum source via a vacuum flow controller and operable to be in fluid communication with a gas source via a gas flow controller.

20. The substrate support assembly of claim **18**, wherein the edge ring includes a chucking electrode disposed therein and coupleable to a power source.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 11,205,978 B2
APPLICATION NO. : 16/713744
DATED : December 21, 2021
INVENTOR(S) : Wayne McMillan et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Specification

Column 4, Line 5, delete "201 B" and insert -- 201B --, therefor.

In the Claims

Column 9, Line 3, Claim 2, after "assembly" delete "of claim 1".

Signed and Sealed this
Tenth Day of May, 2022

Katherine Kelly Vidal

Katherine Kelly Vidal
Director of the United States Patent and Trademark Office